

CLAIMS

What is claimed is:

1. A device for monitoring pressure in a fluid system comprising:
a pressure monitor for placement in communication with a fluid in said
5 fluid system, said pressure monitor generating a signal representative of a
measured pressure; and
a control means for receiving said signal representative of said measured
pressure and comparing said measured pressure to a reference.
- 10 2. The device of claim 1 wherein said pressure monitor and said control
means are placed in communication with a fluid system.
3. The device of claim 2 wherein said fluid system comprises a liquid
chromatography system.
- 15 4. The device of claim 2 wherein said fluid system comprises a liquid
chromatography sample injection system.
5. The device of claim 2 wherein said fluid system comprises:
20 at least one fluid path section having a first end and a second end;
at least one fluid connection means having a plurality of ports for
interconnection and responsive to a connect command signal to assume a first
position wherein fluid flows between at least two of said ports and responsive to
a disconnect command signal to assume a second position in which fluid does
25 not flow between any of said plurality of ports, at least one port connected to
said first end for forming a fluid system configuration; and
a controllable pressure source connected to said second end and
responsive to a pressure command signal to create a source pressure on fluid in
said fluid system.
- 30 6. The device of claim 5 wherein said at least one fluid connection means
has at least one first port and a second port, said at least one first port connected

to a first fluid path section and said second port connected to a second fluid path section.

7. The device of claim 6 wherein said control means is a source of said
5 pressure command signal.

8. The device of claim 7 wherein said control means is a source of said connect command signal and said disconnect command signal.

10 9. The device of claim 5 wherein said controllable pressure source is a metering syringe.

10. The device of claim 5 wherein said pressure monitor is disposed in one of said at least one fluid path sections.

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11. The device of claim 10 wherein said control means issues at least one disconnect command signal to place at least one of said fluid connection means in said second position, creating a first closed fluid system configuration.

20 12. The device of claim 11 wherein said control means monitors said measured pressure over time to detect a degradation of said measured pressure indicative of a lack of fluid integrity in said first closed fluid system configuration.

25 13. The device of claim 6 wherein said at least one fluid connection means is a multiport valve having at least one first position and said second position.

14. The device of claim 11 wherein said control means issues a pressure command signal, said pressure command signal to create a predetermined
30 pressure, and said control means reports an error if said measured pressure does not reach a predetermined value within a specified period of time after sending said pressure command signal.

15. The device of claim 10 wherein said control means has a library of entries comprising command signals to be sent, time, and normal measured pressure values and said control means issues said command signals for one entry and compares a set of received measured pressures to said normal
5 measured pressure values, reporting differences between said pressures that exceed a preset threshold.

16. The device of claim 2 wherein said fluid system comprises:
a monitored fluid path section having a first end and a second end;
10 a first and second fluid subsystem each fluid subsystem comprising at least one fluid path section having a section first end and a section second end, at least one fluid connection means having a plurality of ports for interconnection and responsive to a connect command signal to assume a first position wherein fluid flows between at least two of said ports and responsive to
15 a disconnect command signal to assume a second position in which fluid does not flow between any of said plurality of ports, at least one port connected to said at least one section first end for forming said fluid subsystem and a controllable pressure source connected to said at least one section second end, said controllable pressure source responsive to a pressure command signal to
20 create a source pressure on fluid in said fluid subsystem, said first fluid subsystem connected to said first end of said monitored fluid path section and said second fluid subsystem connected to said second end of said monitored fluid path section, said pressure monitor in communication with said monitored fluid path section.

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17. The device of claim 16 wherein said control means monitors said signal from said pressure monitor and compares said measured pressure values over time for identifying degradations indicative of reduced fluid integrity of said fluid circuit.

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18. The device of claim 16 in which said control means issues at least one connect command signal and at least one disconnect command signal to form a first closed fluid circuit, issues at least one pressure command signal to apply

said source pressure from one controllable pressure source, receives said signal representative of said measured pressure and identifies non-leaking components based on a stability of said measured pressure in said first closed fluid circuit.

5 19. The device of claim 18 wherein said controllable pressure source is responsive to said pressure command signal to compress said fluid in said fluid system until a desired source pressure is achieved.

10 20. The device of claim 18 wherein said control means forms a series of closed fluid circuits, each successive closed fluid circuit incorporating at least one previously untested fluid path section or fluid connection means or controlled pressure source, and said control means monitors said measured pressure of each successive closed fluid circuit to identify further non-leaking components of said closed fluid circuit and reports a successive closed fluid
15 circuit containing leaking components as identified by a decreasing measured pressure.

21. The device of claim 16 wherein at least one of said at least one valve means comprises an interconnection of valve means.

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22. The device of claim 21 wherein said fluid connection means is a multiport valve means.

23. The device of claim 5 wherein said fluid system has been calibrated
25 yielding a viscosity calibration factor, one said fluid path section is in communication with said pressure monitor and said control means receives a measured pressure signal in response to movement of fluid in said fluid system to calculate a viscosity of said fluid

30 24. The device of claim 23 for efficiently washing said fluid system using said monitored pressure, wherein said controllable pressure source comprises a first wash syringe containing a first wash fluid and a first fluid connection means to select said first wash syringe, and said control means executes a series

of instructions that cause said control means to send connect command signals and disconnect command signals to said at least one connection means to configure said fluid system, to send at least one connect command signal to said first connection means to select said first wash syringe and to send a first
5 pressure command signal to said first wash syringe while monitoring said measured pressure until said measured pressure equals a predetermined first wash pressure, to flow said first wash fluid at said first wash pressure until a predetermined volume of first wash fluid has been provided.

10 25. The device of claim 24 for efficiently washing said fluid system using said monitored pressure wherein said controllable pressure source further comprises a second wash syringe containing a second wash fluid and said first fluid connection means selects between said first and said second wash syringe, said control means further executing a series of instructions that cause said
15 control means to send at least one connect command signal to said first connection means to select said second wash syringe and send a second pressure command signal to said second wash syringe until said measured pressure equals a predetermined second wash pressure, and to flow said second wash fluid at said second wash pressure until a predetermined volume of second wash
20 fluid has been provided.

26. A method of monitoring pressure in a fluid system comprised of at least one fluid path section having a first end and a second end and at least one controllable pressure source connected to said first end of at least one fluid path
25 section and responsive to a pressure command signal to create a source pressure in said at least one fluid path section, said method comprising:

providing a device comprising:

a pressure monitor for placement in communication with a fluid
in said fluid system, said pressure monitor generating a signal
30 representative of a measured pressure;

a control means for receiving said signal representative of said measured pressure and for sending signals to said fluid system;

placing said pressure monitor in communication with a fluid in said at least one fluid path section;

issuing a pressure command signal from said control means to one of said controllable pressure sources to generate said source pressure in said at least one fluid path section; and

comparing said measured pressure to a reference to identify errors in said fluid system.

27. The method of claim 26 wherein said fluid system further comprises at least one fluid connection means having a plurality of ports for interconnecting with said at least one controllable pressure source and said at least one fluid path section, said fluid connection means being capable of assuming at least a first position wherein fluid flows between at least two of said plurality of ports in response to a connect command signal and a second position in which no fluid flows in response to a disconnect command signal, said fluid connection means connected to an end of said fluid path section.

28. The method of claim 27 wherein said fluid connection means is a multiport valve.

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29. The method of claim 27 wherein said fluid system comprises a first fluid connection means having at least a first port and a second port, a second fluid connection means having at least a first port and a second port, and one of said at least one controllable pressure sources is connected to said first port of said first fluid connection means, said second port of said first fluid connection means is connected to a first end of a first fluid path section, a second end of said first fluid path section is connected to a first port of a second connection means, and said method further comprises:

sending at least one connect command signal and disconnect command signal to said first and second fluid connection means to place said first connection means in said first position and said second connection means in said second position for creating a closed system;

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sending a pressure command signal to said controllable pressure source to generate a predetermined source pressure; and

comparing said measured pressure to said predetermined source pressure and reporting an establishment error if a difference is greater than a first

5 allowed amount.

30. The method of claim 29 further comprising after said comparing step: waiting a predetermined length of time;

comparing a current measured pressure to said predetermined source
10 pressure: and

reporting a leak error if a difference is greater than a second allowed amount.

31. The method of claim 28 comprising:

15 providing said control means with a library having entries comprising sets of command signals and sets of normal pressure values;

issuing the command signals of an entry from said control means;

comparing said measured pressures to said normal pressure values; and

reporting differences that exceed a preset threshold.

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32. The method of claim 31 wherein said fluid system further comprises a second controllable pressure source connected to said second port of said second fluid connection means, said method further comprising:

25 sending at least one connect command signal and disconnect command signal from said control means to said first and second fluid connection means to place said first fluid connection means in said second position and said second fluid connection means in said first position in which fluid flows between said first fluid path and said second controllable pressure source;

30 sending at least one said pressure command signal to said second controllable pressure source for setting said source pressure; and

monitoring said signal from said pressure monitor and identifying non-leaking components based on a stability of said measured pressure over time.

33. The method of claim 31 wherein said fluid system comprises a monitored fluid path section having a first end and a second end and a first and second fluid subsystem each fluid subsystem comprising at least one fluid path section having a section first end and a section second end, at least one fluid connection means having a plurality of ports for interconnection and responsive to a connect command signal to assume a first position wherein fluid flows between at least two of said ports and responsive to a disconnect command signal to assume a second position in which fluid does not flow between any of said plurality of ports, at least one port connected to said at least one section first end for forming said fluid subsystem and a controllable pressure source connected to said at least one section second end, said controllable pressure source responsive to a pressure command signal to create a source pressure on fluid in said fluid subsystem, said first fluid subsystem connected to said first end of said monitored fluid path section and said second fluid subsystem connected to said second end of said monitored fluid path section, said pressure monitor in communication with said monitored fluid path section, said method further comprising:

20 sending at least one said connect command signal and disconnect command signal to said second fluid subsystem to create a configuration wherein fluid flows between a controllable pressure source of said second subsystem to said monitored fluid path section;

sending at least one said connect command signal and disconnect command signal to said first fluid subsystem to create a configuration wherein fluid does not flow to said first subsystem;

25 sending at least one said pressure command signal to said controllable pressure source of said second subsystem for setting said source pressure; and monitoring said signal from said pressure monitor and identifying non-leaking components based on the stability of said measured pressure over time.

30 34. The method of claim 33 further comprising:

sending at least one said connect command signal and disconnect command signal to said first fluid subsystem to create a configuration wherein

fluid flows between a controllable pressure source of said first subsystem to said monitored fluid path section;

sending at least one said connect command signal and disconnect command signal to said second fluid subsystem to create a configuration

5 wherein fluid does not flow to said second subsystem;

sending at least one said pressure command signal to said controllable pressure source of said first subsystem for setting said source pressure; and

10 monitoring said signal from said pressure monitor and identifying additional non-leaking components based on the stability of said measured pressure over time.

35. The method of claim 33 wherein said fluid connection means comprises an interconnection of a plurality of valve means.

15 36. The method of claim 26 wherein said fluid system is an autosampler for a liquid chromatography system.

37. A method of determining viscosity of a fluid in a calibrated fluid system having a viscosity calibration factor, said fluid system comprising a controllable
20 pressure source responsive to a pressure command signal to create a source pressure on said fluid, at least one fluid path section having an open end and a second end, and said controllable pressure source connected to said second end of said at least one fluid path section, said method comprising:

providing a device comprising:

25 a pressure monitor for placement in communication with a fluid in said fluid system, said pressure monitor generating a signal representative of a measured pressure;

a control means for receiving said signal representative of said measured pressure and for sending signals to said fluid system;

30 placing said pressure monitor in communication with said fluid in said at least one fluid path section at a known position on said fluid path section;

issuing a pressure command signal from said control means to said controllable pressure source to create said source pressure, said source pressure causing said fluid to flow; and

calculating a viscosity of said fluid using said measured pressure and
5 said viscosity calibration factor.